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Impact of Severe Earthquake on the Occurrence of Acute Coronary Syndrome and Stroke in a Rural Area of Japan

— Experience From the Noto Peninsula Earthquake —

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Background: Although acute coronary syndrome (ACS) and stroke are known to increase after earthquake, few data exist regarding the effect of earthquake on these cardiovascular events in rural areas.

Methods and Results: The Noto Peninsula earthquake with a magnitude of 6.9 occurred at 9:45 a.m. on 25 March 2007. The first case of ACS occurred approximately 15 min later, whereas cerebral hemorrhage (CH) occurred 72 h after the onset of earthquake. During the 35 days after earthquake, among 49 patients who were attended by local ambulance, 5 patients with ACS (10.2%) and 8 with CH (16.3%) were documented and 4 died. The total number of both ACS and CH cases was greater than the averages for the same period of the past 3 years in this area (2.0 vs 5 and 2.3 vs 8, P<0.01). Interestingly, the most cases of ACS had occurred within 7 days after earthquake and for CH not until 35 days later.

Conclusions: Even in rural areas a severe earthquake results in increased incidence of ACS and CH, which can occur at different times after the event, although the effects of other environmental factors should be further investigated. (*Circ J* 2009; **73:** 1243 – 1247)

Key Words: Acute coronary syndrome; Cerebral hemorrhage; Earthquake; Stress

There are several reports that the prevalence of cardiovascular disorders increases after disasters such as major earthquake. After the Northridge earthquake, which struck Los Angeles in 1994, there was a significant increase in cardiac mortality.[1] In Japan, Ogawa et al reported that mortality from acute coronary syndrome (ACS) increased after the Great Hanshin–Awaji earthquake in 1995[2] and it is also reported that stroke, including cerebral hemorrhage (CH), increases after earthquakes.[3] These data were obtained in relatively urban areas, and there is relatively little information regarding the effect of earthquake on cardiovascular events in rural areas of Japan where most of the population is >65 years old.

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At 9:45 am on March 25, 2007, a huge earthquake registering 6.9 on the Richter scale struck the Noto Peninsula, which located in northern Japan. In particular, Wajima City at the top of the peninsula suffered the greatest damage. In this area of 426.24 km^2, live approximately 34,000 people, 35% of whom are >65 years old. We investigated the incidence of ACS and CH after the earthquake.

Methods

Data Collection

Wajima City Hospital is the only general hospital and plays a main role in the public health of the area. Almost all ambulance visits, approximately 700 times per year in Wajima City, come to the hospital. After the earthquake, we investigated patients who were admitted to hospital and patients who were transferred to back-up hospitals for intense or advanced care for the 35 days from March 25 to April 29 2007. We also investigated records of patients from the same period in the past 3 years as controls. We compared the prevalence of ACS and cerebrovascular diseases, including CH and cerebral infarction, in each 7 day period from March 25 to April 29 in the past 3 years.

Diagnostic Criteria

ACS was diagnosed by the combination of typical chest symptoms, ECG changes such as ST-segment elevation in at least 3 leads, asynergy on transthoracic echocardiography, increased levels of creatine kinase, aspartate aminotransferase and lactate dehydrogenase, and coronary angiography findings. In patients who were diagnosed as having transient left ventricular apical ballooning by transthoracic

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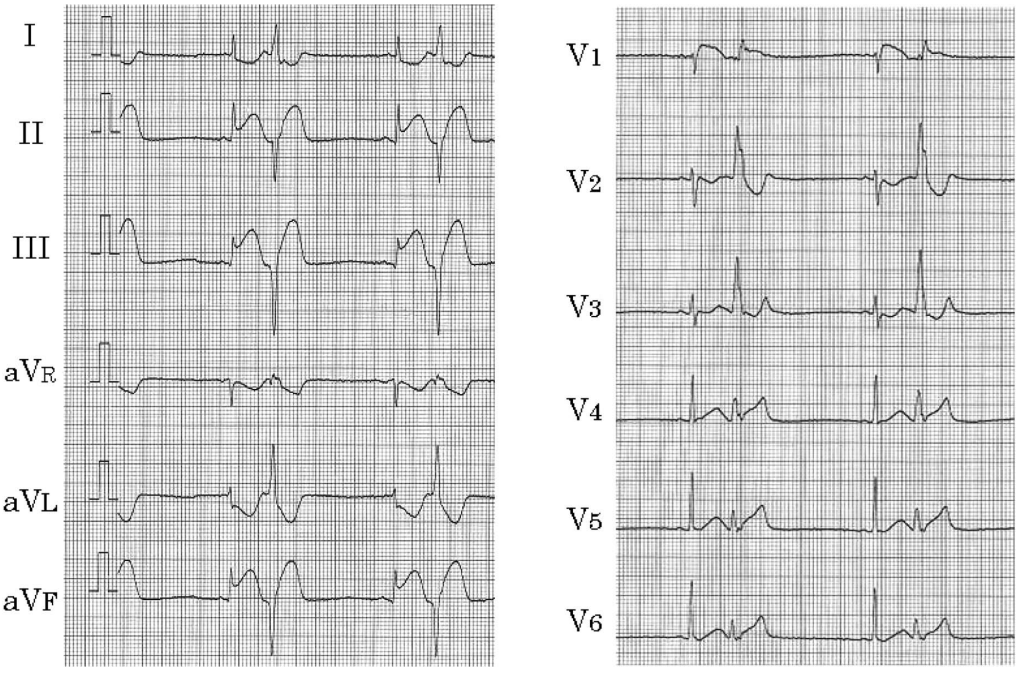

Figure 1. ECG showed remarkable ST elevation in leads II, III, aVF and V1 and ST depression in I, aVL (Case 1 in Table). Bigeminy of ventricular premature contraction can also be seen.

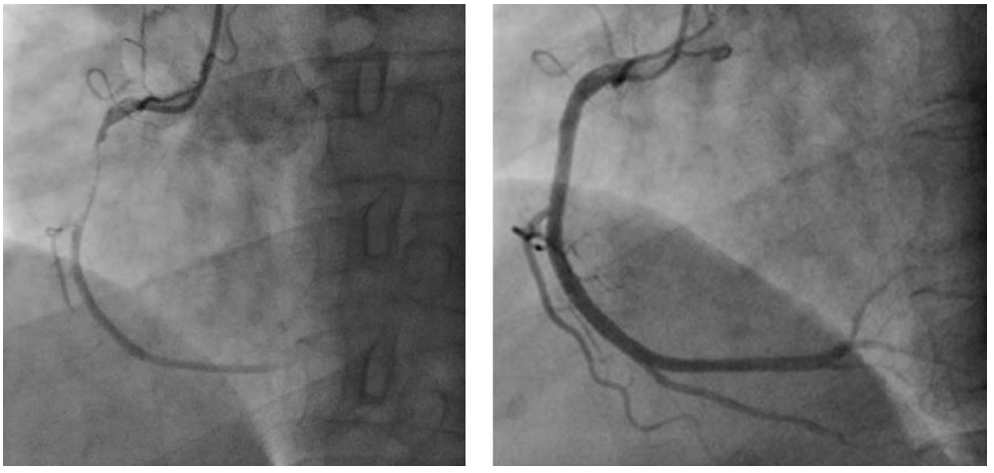

Figure 2. Coronary angiography showed severe stenosis in the proximal right coronary artery (Case 1 in Table), probably associated with thrombus (**Left**). A coronary stent was implanted in the culprit lesion (**Right**).

echocardiography, coronary angiography and left ventriculography were also performed. CH was diagnosed by computed tomography and cerebral infarction was diagnosed by neurological symptoms, physical findings, computed tomography and magnetic resonance imaging.

Statistical Analysis

Data were expressed as mean±SD. For the statistical analysis, the number of patients after the earthquake in 2007 was compared with the average of the previous 3 years under a Poisson distribution, with the mean value taken as the mean number for the previous 3 years. Values of $P<0.05$ were considered to be statistically significant.

Results

According to the official record regarding the number of victims directly related to this earthquake[4], only 1 person died in a crush accident just after the onset. There were 12,655 patients who visited Wajima City Hospital from March 25 to April 29 in 2007. Among them, there were 49 emergency cases related to the ambulance section of a fire station.

ACS

The first patient of 57 year-old woman with ACS was admitted to hospital 45 min after the earthquake. She felt chest discomfort approximately 15 min after the event and her family took her to hospital. She was diagnosed as having ACS by ECG, which showed ST-segment elevation in leads II, III, aVF and V1 (**Figure 1**). She was transferred to a

Table. Clinical Characteristics of the Patients With ACS or Stroke After the 2007 Earthquake

Case no.	Age (years)	Sex	Arrival time	Days after earthquake	BP on admission (mmHg)
ACS					
1	57	F	10:30 a.m.	0	160/98
2	76	F	0:45 p.m.	0	168/115
3	77	M	5:05 a.m.	3	194/88
4	91	F	8:15 a.m.	11	78/54
5	57	M	2:20 a.m.	24	126/90
Mean±SD	72±15		7:47±4:09 a.m.	8±10	145±45/89±22
CH					
1	65	F	1:50 a.m.	3	176/92
2	57	M	2:00 a.m.	8	154/70
3	78	F	11:00 p.m.	12	176/80
4	85	F	11:00 p.m.	15	156/76
5	89	F	10:30 a.m.	25	260/130
6	51	M	7:10 a.m.	30	172/72
7	83	F	0:50 a.m.	33	162/80
8	70	M	6:40 p.m.	33	230/116
Mean±SD	72±14		12:22±3:36 p.m.	20±12	186±38/90±22

ACS, acute coronary syndrome; BP, blood pressure; CH, cerebral hemorrhage.

back-up hospital and underwent emergency coronary angiography and percutaneous coronary intervention (**Figure 2**).

Among 49 patients who were brought in by ambulance, there were 5 patients with ACS (10.2%: 2 men and 3 women, mean age 72±15 years), which occurred within 5 weeks, particularly within the first 7 days after the earthquake. From the medical records, 2 patients had a history of diabetes mellitus, and 3 had hypertension. Except for the patient with diabetes, all medications were discontinued.

Interestingly, 4 cases of ACS occurred in the morning during the observation period (**Table**). The 4 patients were transferred to back-up hospitals and none died from cardiac disease. As for prevalence of ACS during the same period in the past 3 years, there was 1 case in 2004, 3 in 2005 and 2 in 2006 (4 men and 2 women, mean age 74±11 years) (**Figure 4**). Thus, the number of case of ACS in 2007 was greater than in the past 3 years. There were only 2 patients with ACS who attended Wajima City Hospital in the next month after this study. Interestingly, the mean age of the patients with ACS was not significantly different between 2007 and in the same period of the past 3 years. During the follow-up period, 1 patient died of cardiac rupture. In addition to ACS, there were 2 cases of transient left ventricular apical ballooning with normal coronary angiography, both of which occurred in the very early morning between 2 a.m. and 3 a.m.

Figure 3. Computed tomography showed a meningioma with intracerebral hemorrhage in the left parietal lobe.

Cerebrovascular Diseases

The first patient with CH visited at 1:50 p.m. 3 days after the earthquake. She had severe headache and her conscious level was 100 on the Japan Coma Scale when she was transferred to Wajima City Hospital. Computed tomography revealed intracerebral hemorrhage and untreated meningioma (**Figure 3**). She was sent to a back-up hospital for advanced care by a neurosurgeon. Within the 35 days after the earthquake 8 patients developed CH (16.3%: 3 men and 5 women, mean age 72±14 years). From the medical records, 3 patients had a history of diabetes mellitus and 6 had hypertension. All medications were discontinued.

Two CH patients were not transferred to back-up hospitals, because there were no indications for surgical treatment, and they died in hospital. Others were sent to a back-up hospital. There were 2.3 CH patients per year during the same period in the past 3 years (5 men and 2 women, mean age 75±13 years). There was a significant increase in the number of CH cases after the earthquake in 2007 in comparison with the past 3 years (2.3 vs 8, $P<0.01$) (**Figure 4**). During the follow-up period, 3 patients died. There were 3 patients with CH in the next month after this study, suggesting that the occurrence of CH was closely related to that of the earthquake. As for the occurrence of cerebral infarction, there were 7 patients after the earthquake in 2007 and 5.3 patients during the same period in the past 3 years, so the incidence of cerebral infarction was not different between 2007 and the past 3 years.

Time Difference in the Occurrence of ACS and CH

ACS mainly occurred within 7 days after the earthquake, whereas CH and cerebral infarction occurred approximately 35 days afterward.

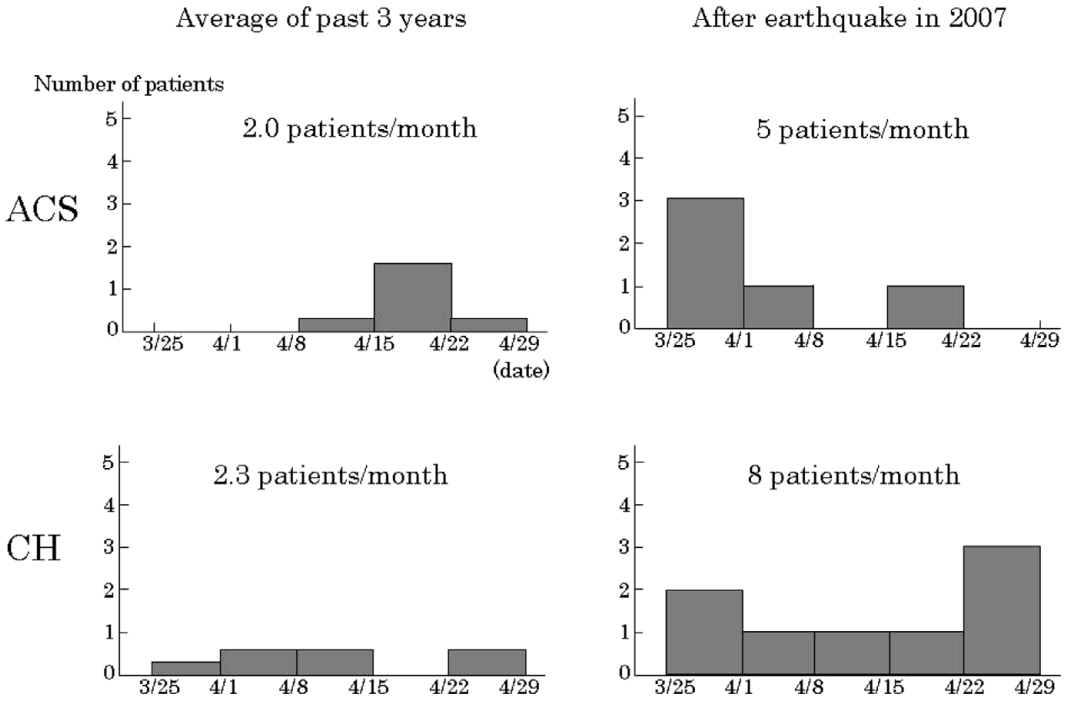

Figure 4. Average number of patients with acute coronary syndrome (ACS, **Upper**) and cerebral hemorrhage (CH, **Lower**) per a week from March 25 to April 29 in the past 3 years (**Left**) and in 2007 (**Right**).

Discussion

Even in rural areas of Japan, the incidence of ACS and CH increases after the occurrence of a severe earthquake. It is important to note that the occurrence of CH increases approximately 35 days after the vent, whereas that of ACS increases within 7 days.

The occurrence of ACS usually increases by 1.3–3.5-fold after earthquake, and cerebrovascular accident is also reported to increase by 1.8-fold after earthquake[5,6] After the Noto Peninsula earthquake, we had 2.5-fold more patients with ACS and 3.5-fold more CH patients compared with the previous 3 years. Although the increase in ACS was similar to that reported in previous studies, the occurrence of CH was greater, probably because of the greater aging of the population in this area.

We observed that ACS occurred from midnight to morning at the time of the earthquake, whereas in the past 3 years in the Wajima area it usually occurred throughout the day. Kloner et al reported that sudden deaths related to cardiovascular disease increased from midnight to 6 a.m. after the earthquake in Los Angeles in 1994[7] which may be related to the morning surge phenomenon that could increase hypertension-induced stress in the coronary artery. It is also possible that vasospasm could contribute to the occurrence of ACS[8]

Although the incidence of cerebral infarction can increase after natural disasters, it has not been elucidated whether or not CH increases at the time of severe disaster. To our knowledge, this is the first report to demonstrate a greater number of patients than usual developing CH after a severe earthquake. It is quite interesting that the number of cases of CH increased approximately 35 days after the earthquake, probably because of continuous elevation of blood pressure associated with emotional stress, although the exact trigger of increased CH is still unknown. It is still unclear, however, why the number of patients with cerebral infarction did not differ from usual. We speculate that the occurrence of CH rather than cerebral infarction could be related to acute and strong emotional stress such as after a severe earthquake.

From this point of view, emotional stress could also induce left ventricular apical ballooning[9] which did occur in 2 patients after the 2007 earthquake. After the Mid-Niigata Prefecture Earthquake in 2004, there were 16 patients with left ventricular apical ballooning and 11 developed it on the day of the earthquake[10] Acute and severe cerebral hemorrhage is sometimes associated with left ventricular apical ballooning[11] Hyperglycemic and hyperosmolar state may contribute to enhancing systemic stress[12] probably due to excessive release of catecholamines from the hearts[13]

Hypertension is related to both cardiovascular and cerebrovascular events. Blood pressure increases immediately after a major earthquake[14] and under these conditions, abruptly increased shear stress may result in the plaque rupture that is associated with ACS. Continuous elevation of blood pressure caused by emotional stress may partly explain why the number of cases of CH increased for several weeks after the earthquake.

Clinical Implications and Study Limitations

Our findings have an important clinical implication for patient care after earthquakes. It was quite striking that there were 4 death in total related to ACS and CH in the acute phase, although the number of victims directly related to the earthquake was only 1[4] This is quite a different pattern to that for earthquakes in urban areas, where many people are killed by the earthquake itself. Therefore, as cardiologists we should be aware of the emotional stress associated with elevated blood pressure, which could result in the development of ACS and CH for at least 1 month after an earthquake.

There remain several limitations. First, the present study analyzed the patients who visited Wajima City Hospital. Although all the patients with ACS and stroke at the time of earthquake should have been transferred to this hospital, it is possible that some were transferred to other hospitals. Therefore, the number of patients does not represent the total number of ACS and CH cases that occurred in this area. Second, although important, we could not examine the contribution of environmental changes such as medications, diet, exercise therapy, sleep status and associated changes in blood pressure because of a lack of precise medical records for each patient. Third, we did not evaluate the degree of emotional stress in each patient who developed ACS or CH. It is quite important to determine the emotional stress of each person immediately after a severe earthquake and, under these conditions, prospective and continuous observation are needed. It is interesting to compare the effects of different kinds of stress on the occurrence of ACH and CH. Coronary events in women could increase in the relative long-term[15] and the effect of other factors, such as bankruptcy, should be further sought.

Conclusion

The incidence of both ACS and CH increased after the 2007 Noto Peninsula earthquake, resulting in more victims than those from the earthquake itself. ACS occurred within 7 days and CH cases increased for 35 days after earthquake. We suggest decreasing physical and emotional stresses to normalize blood pressure, not only in the acute phase of the event, but also in the long term.

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